

Semantic-Web based Annotation and Reasoning for Temporal Information in EHRs

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BIOMEDICAL ONTOLOGY



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Introduction

- Time is essential in clinical research
 - Uncover temporal pattern
 - Disease level
 - Patient level
 - Explain past events
 - Predict future events

Introduction

- Vast amount of data
- Structured data
- Data embedded in narratives
- Many temporal relations are not *explicitly* stated in the clinical narratives, but rather needs to be inferred

Temporal Relation Reasoning (Example)

- *Patient's INR value is below normal (Event 1) today. (note date: 01/26/07)*
- *He has had the chills and body aches (Event 2) before the abnormal test. (Event 3)" (note date: 01/26/07)*
- *On Jan. 30, 2007, patient started Coumadin dosing plan of 1.0 mg (Event 4).(note date: 02/09/07)*
- *Question: "did the patient experience body aches before he started the Coumadin dosing plan?" (was Event 2 before Event 4?)*

Temporal Relation Reasoning (Example)

- *Patient's INR value is below normal (Event 1) today. (note date: 01/26/07)* *Event1 = Event3*
- He has had the *chills and body aches (Event 2) before the abnormal test. (Event 3)* (note date: 01/26/07)
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Event1 = Event3

+

Event2 before Event3

→

Event2 before Event1

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Event1 = Event3

+

Event2 before Event3

→

Event2 before Event1

Event1 01/26/07 +

Event4 01/30/07

→

Event1 before Event4

Temporal Relation Reasoning (Example)

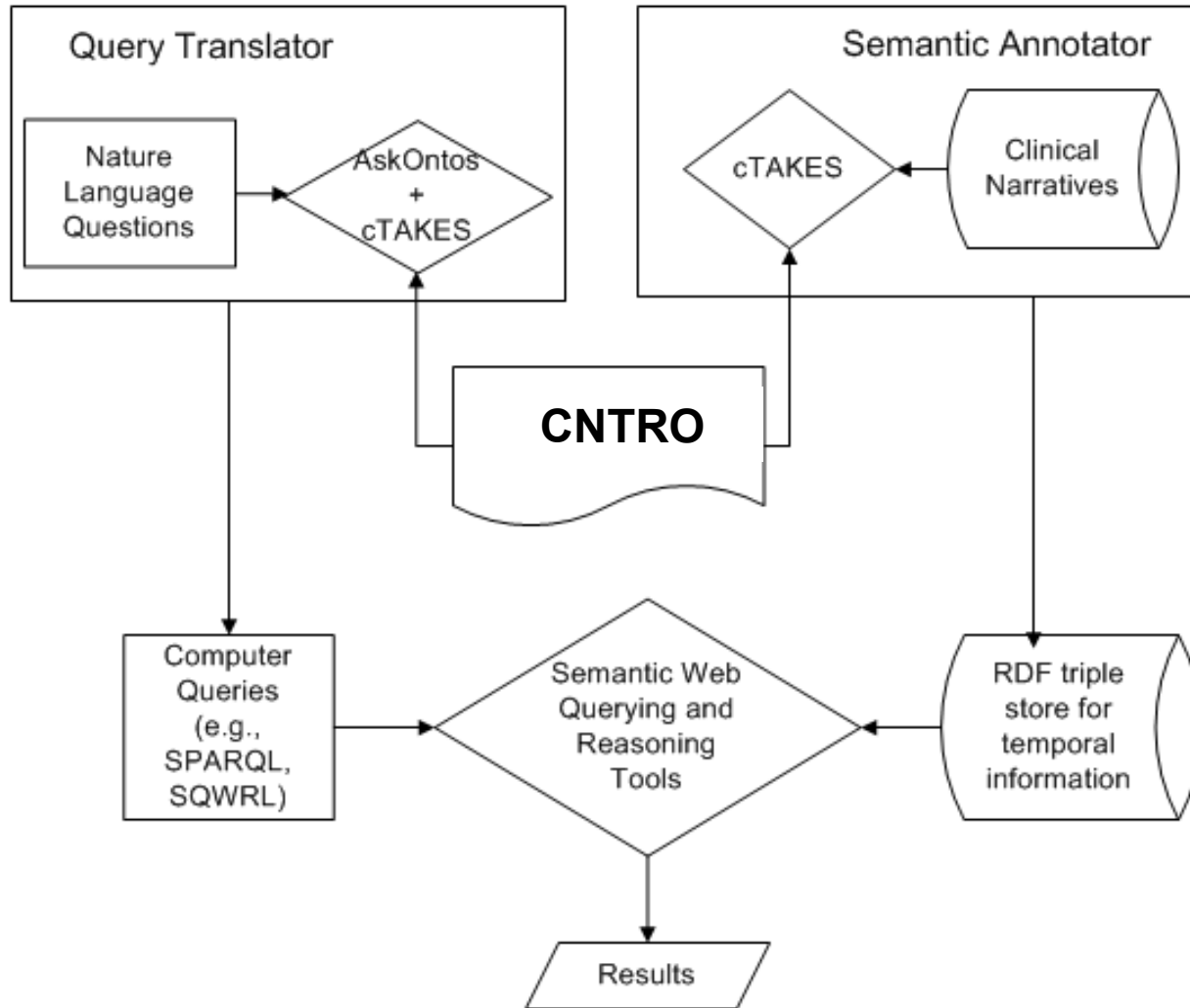
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+
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Event2 before Event3
→
Event2 before Event1
- *On Jan. 30, 2007, patient started Coumadin dosing plan of 1.0 mg (Event 4).(note date: 02/09/07)*
Event1 01/26/07 +
Event4 01/30/07
→
Event1 before Event4
- *Question: "did the patient experience body aches before he started the Coumadin dosing plan?"*
Event2 before Event4

Introduction

The Semantic Web provides a suitable environment for temporal data representation and reasoning:

- Standard mechanism with explicit and formal semantic definition
- OWL DL
- SWRL
- Reasoning tools, querying and storage mechanisms

System Overview

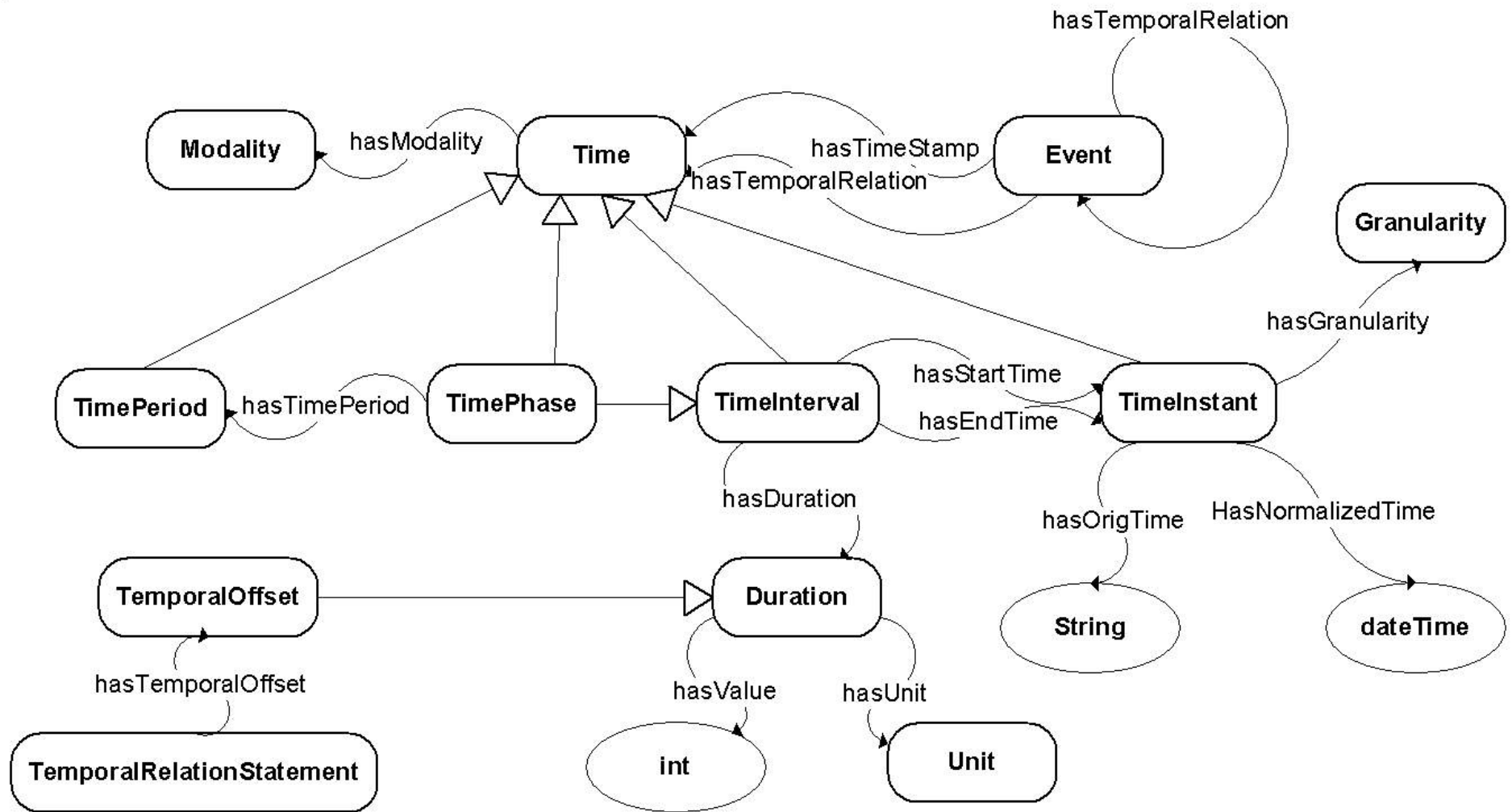


CNTRO Ontology

Clinical Narrative Temporal Relation Ontology (CNTRO)

- Event
- Time
 - Time Instant
 - Time Interval
 - Time Phase
 - Time Period
- Temporal Relation

CNTRO Overview



CNTRO Evaluation

153 sentences with temporal information

- 178 events
- 98 time instants
- 10 time intervals
- 53 time phases
- 170 temporal relations
- 142/153 sentences were represented without losing any time-related information

Semantic Annotation

Semantic Annotation Tool

- **Protégé plugin**
- **RDF exporter**
- **Connects to the temporal reasoning framework API**
- **Will connect with Mayo's cTAKES pipeline**

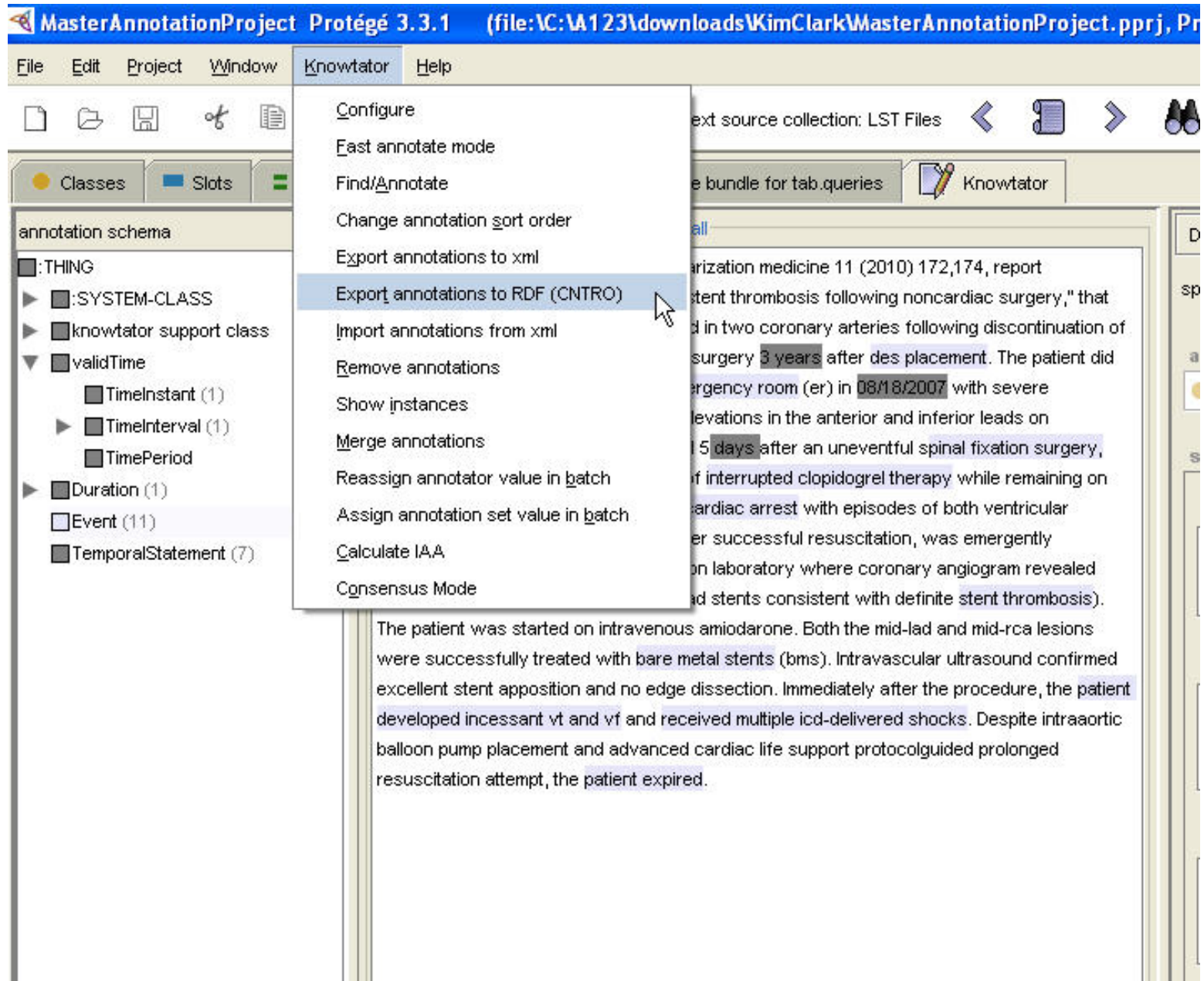
Classes Slots Forms Instances Queries Knowtator

annotation schema

- :THING
 - :SYSTEM-CLASS
 - knowtator support class
 - validTime
 - Duration (1)
 - Event (11)
 - TemporalStatement (7)

text source: File 14.txt filter: show all

Parikh et al in cardiovascular revascularization medicine 11 (2010) 172,174, report "simultaneous dual coronary very late stent thrombosis following noncardiac surgery," that simultaneous stent thrombosis occurred in two coronary arteries following discontinuation of clopidogrel for an elective non-cardiac surgery 3 years after des placement. The patient did well until he presented again to the emergency room (er) in 08/18/2007 with severe retrosternal chest pain and diffuse st elevations in the anterior and inferior leads on electrocardiogram. This event occurred 5 days after an uneventful spinal fixation surgery, which had been preceded by a week of interrupted clopidogrel therapy while remaining on aspirin. In the er, the patient went into cardiac arrest with episodes of both ventricular fibrillation (vf) and pulseless vt and, after successful resuscitation, was emergently transferred to the cardiac catheterization laboratory where coronary angiogram revealed occlusion of both his mid-rca and mid-lad stents consistent with definite stent thrombosis). The patient was started on intravenous amiodarone. Both the mid-lad and mid-rca lesions were successfully treated with bare metal stents (bms). Intravascular ultrasound confirmed excellent stent apposition and no edge dissection. Immediately after the procedure, the patient developed incessant vt and vf and received multiple icd-delivered shocks. Despite intraaortic balloon pump placement and advanced cardiac life support protocolguided prolonged resuscitation attempt, the patient expired.



The screenshot displays the Protégé 3.3.1 application window. The title bar reads "MasterAnnotationProject Protégé 3.3.1 (file:IC:\A123\downloads\KimClark\MasterAnnotationProject.pprj, Pr". The menu bar includes "File", "Edit", "Project", "Window", "Knowtator", and "Help". The "Knowtator" menu is open, showing options such as "Configure", "Fast annotate mode", "Find/Annotate", "Change annotation sort order", "Export annotations to xml", "Export annotations to RDF (CNTRO)", "Import annotations from xml", "Remove annotations", "Show instances", "Merge annotations", "Reassign annotator value in batch", "Assign annotation set value in batch", "Calculate IAA", and "Consensus Mode". The "Export annotations to RDF (CNTRO)" option is highlighted by the mouse cursor. On the left, the "Classes" pane shows an "annotation schema" with a tree structure including "THING", "SYSTEM-CLASS", "knowtator support class", "validTime" (with sub-classes "TimeInstant (1)", "TimeInterval (1)", and "TimePeriod"), "Duration (1)", "Event (11)", and "TemporalStatement (7)". The main workspace shows a text editor with a medical text snippet: "arization medicine 11 (2010) 172,174, report stent thrombosis following noncardiac surgery," that d in two coronary arteries following discontinuation of surgery 3 years after des placement. The patient did emergency room (er) in 08/18/2007 with severe elevations in the anterior and inferior leads on 15 days after an uneventful spinal fixation surgery, of interrupted clopidogrel therapy while remaining on cardiac arrest with episodes of both ventricular er successful resuscitation, was emergently on laboratory where coronary angiogram revealed ad stents consistent with definite stent thrombosis). The patient was started on intravenous amiodarone. Both the mid-lad and mid-rca lesions were successfully treated with bare metal stents (bms). Intravascular ultrasound confirmed excellent stent apposition and no edge dissection. Immediately after the procedure, the patient developed incessant vt and vf and received multiple icd-delivered shocks. Despite intraaortic balloon pump placement and advanced cardiac life support protocolguided prolonged resuscitation attempt, the patient expired.

Temporal Reasoning Framework

Temporal Relation Reasoning

- Temporal Representation Normalization
- OWL DL Reasoning
- SWRL-based Reasoning

Implementation Status

- *findEvent(searchText)*
 - returns a list of events that match the searching criteria. Currently we look for events based on text search.
- *GetEventFeature(event, featureflag)*
 - returns a specific time feature for a given event.
 - Sample query:
 - When was the patient diagnosed with diabetes?
 - When did the patient start his chemotherapy?

Implementation Status

- *getDurationBetweenEvents(event1, event2)*
 - returns the time interval between two events.
 - Sample query: How long after the patient was diagnosed colon cancer did he start the chemotherapy?
- *getDuration(event)*
 - returns the duration of a given event.
 - Sample query: How long did the symptoms of rectal bleeding last?

Implementation Status

- *getTemporalRelationType(event1, event2)*
 - returns the temporal relations between two events if it can be retrieved or inferred.
 - Sample query: Was the CT scan after the colonoscopy?
- *getTemporalRelationType(event1, time)*
 - returns the temporal relations between an event and a specific time if it can be inferred or retrieved.
 - Sample query: Is there any behavior change within a week of the test?

Implementation Status

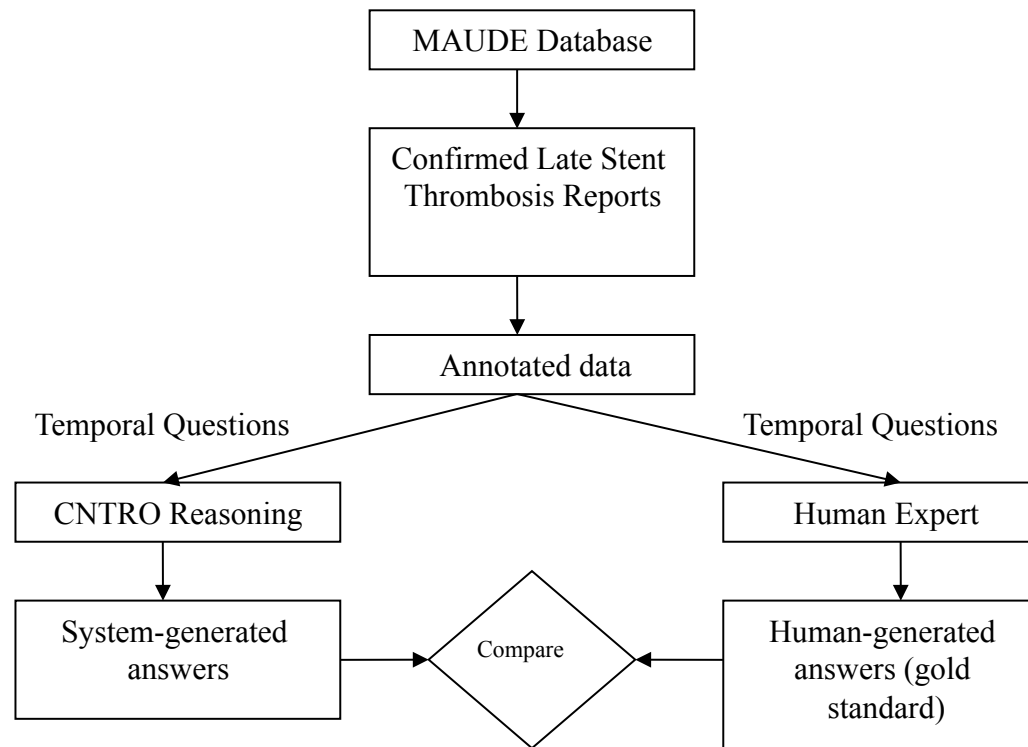
sortEventsByTemporalRelationsOrTimeline(events)

- returns the order (timeline) of a set of events.
- sample query:
 - What is the tumor status timeline as indicated in the patient's radiology note?
 - What is the treatment timeline as recorded in oncology notes?
 - When was the first colonoscopy done?
 - When was the most recent glucose test?

Pilot Study

- Late stent thrombosis adverse event
- Complaint files from Manufacturer and User Facility Device Experience (MAUDE) database
- Detect potential temporal patterns within complaint files of similar adverse events

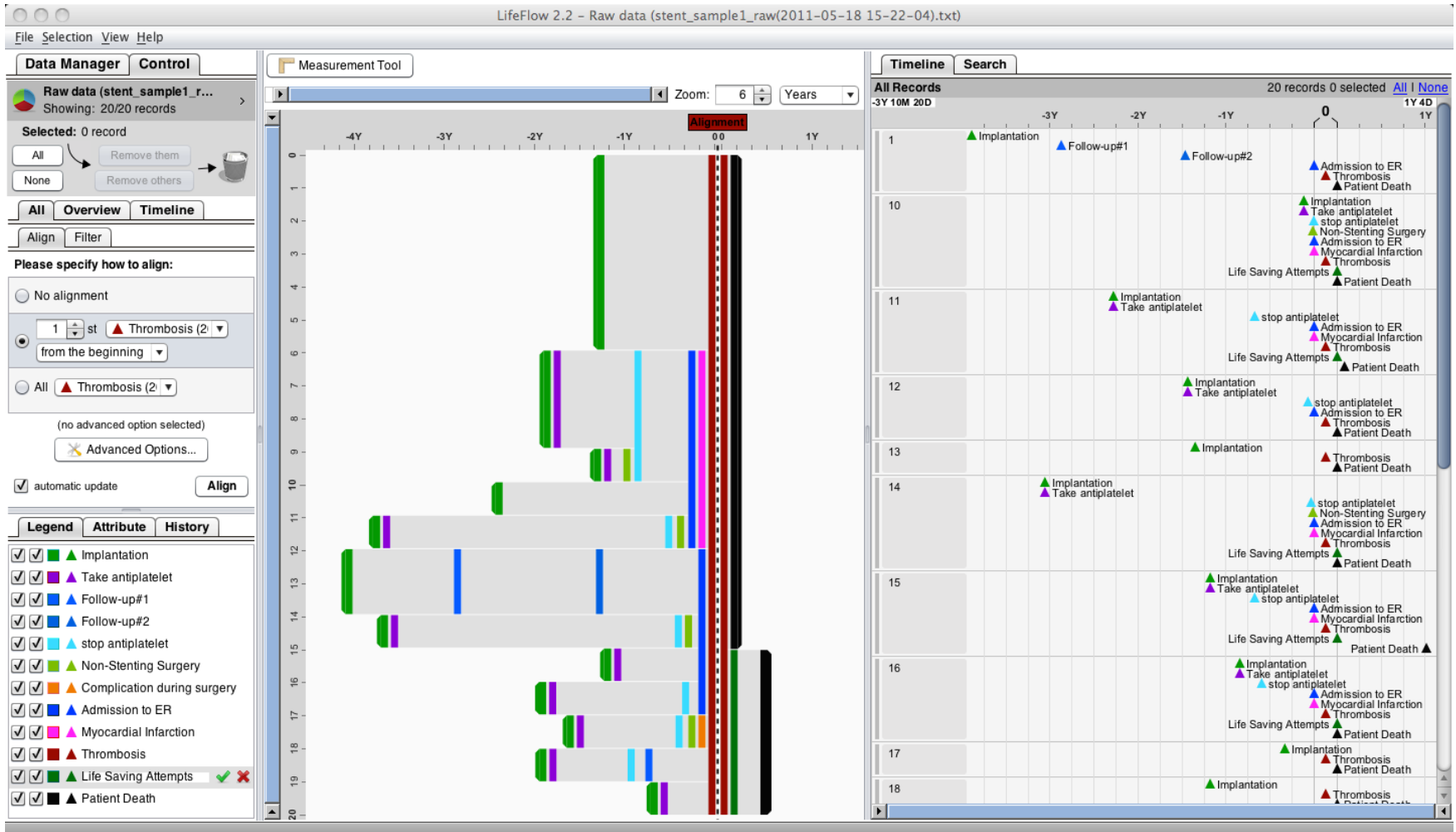
Pilot Study



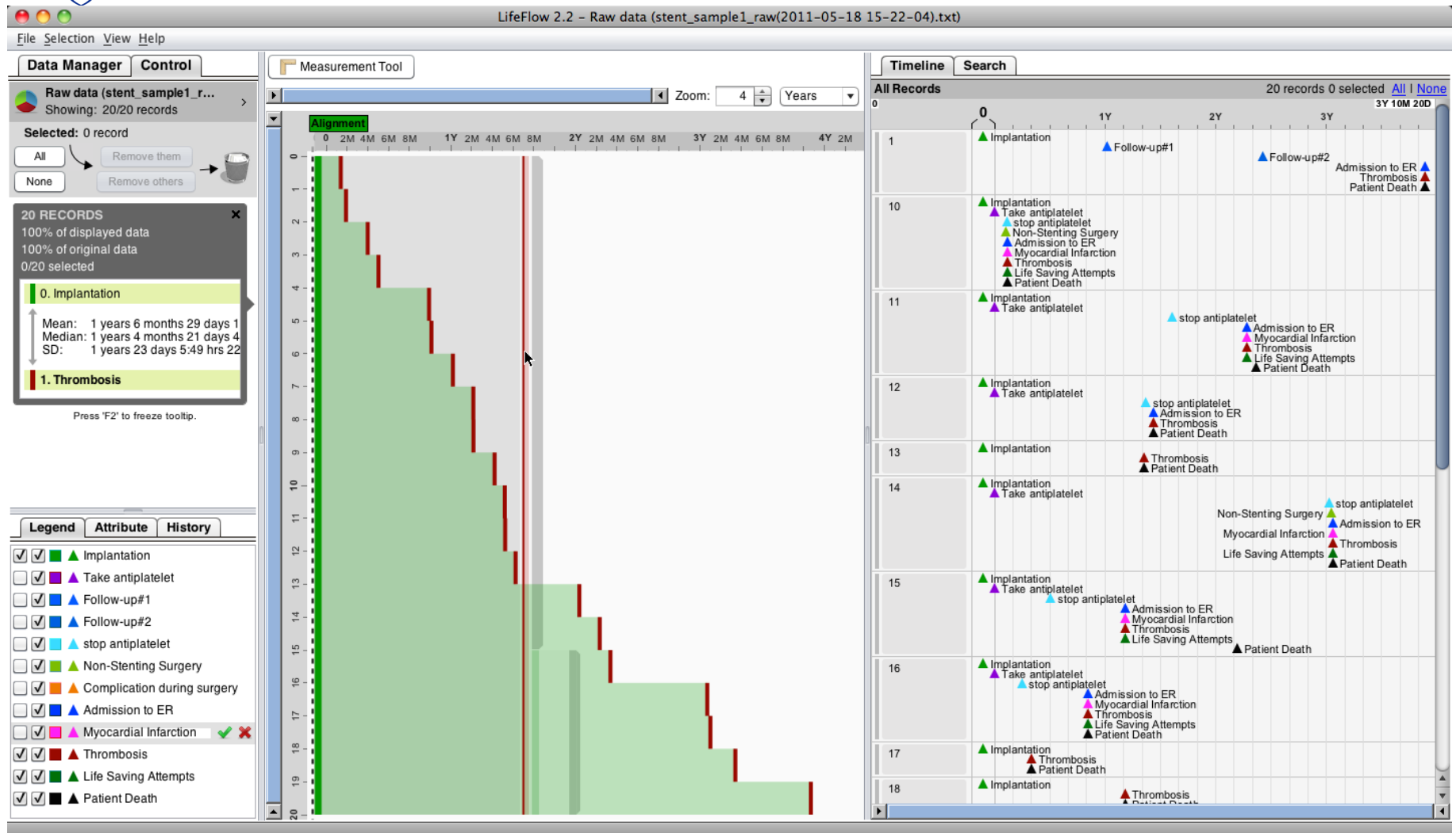
Pilot Study

- Evaluation
 - System answered 65 out of 73 questions correctly
 - Accuracy: 89.04%
- Errors caused by ambiguities in annotations

Connection to LifeFlow (Very Preliminary)



Aligned by thrombosis dates



Time from implantation to thrombosis

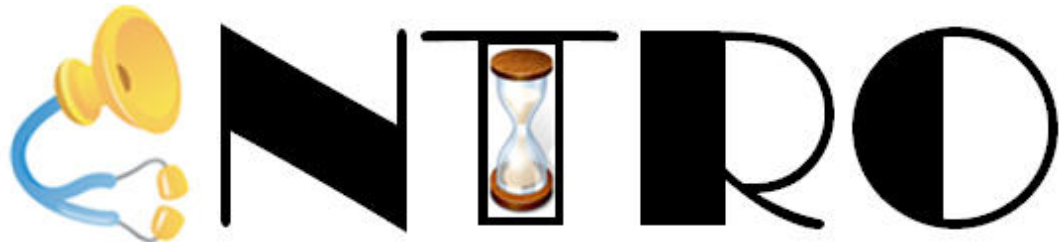
Connection to LifeFlow (Very Preliminary)

- **Relative time information**
- **Uncertainty**
- **Known sequence, unknown duration**
- **Time intervals**

Summary

- A more robust and semantically crisp model
- A semi-automatic annotation system
- A temporal relation reasoning framework
- A user friendly querying system

CNTRO.ORG





- Individual Workshop Papers Due: June 29, 2011
- Notification of Acceptance: July 29, 2011
- Camera Ready: August 12, 2011 (hard deadline for publication)
- Submission to Journal Special Issue: 1st October 2011
- Notification to Journal authors: 15 December 2011

<http://informatics.mayo.edu/CNTRO/index.php/Events/MIXHS11>

